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STRATEGIES FOR INTEGRATED DEVELOPMENT OF THE ELECTRONICS INDUSTRY INCLUDING SOFTWARE

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Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

The following abbreviations are used in this report:

ASIC	Applied specific integrated circuits
EEC	European Economic Community
CEPII	Centre d'études de prospectives et d'informations internationales
SMC	Surface mounted components
OAE	Organization of American States
OEM	Original equipment manufacturing
REMLAC	Regional micro-electronic systems for Latin America and the Caribbean
SEI	Secretariat for Informatics
VAM	Value added in manufacturing

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INTRODUCTION

The electronics industry covers the totality of industrial activities in which products are turned out for the transmission of information and/or the processing of information, using for that purpose electronic techniques, i.e. techniques utilizing variations in electrical parameters to code the information. It is basically an industry for electronic construction that builds and assembles, starting with the building bricks which are the specific components that it needs, systems intended for different categories of clients: the public at large (mass consumers), the industrialists and so forth.

The electronics industry turns out a considerable quantity of products, which one can classify as follows:

- Components: resistances, condensers, transistors, printed circuits, integrated circuits, microprocessors and so forth;

- Electronics for mass consumption: radio sets, hi-fi equipment, video recorders, compact disc readers and so forth;

- Industrial electronics: telecommunication equipment, measuring and regulating apparatus, computers and so forth.

Given this classification, the electronics industry appears to be extremely diversified when compared with the state it was in only 20 or so years ago. The fundamental change has been brought about through the considerable progress at certain higher scientific and technological levels, which has assigned basic importance to some of the components common to all the systems manufactured by the electronics industry. The transistor in 1947, the integrated circuit in 1959 and above all the microprocessor - a veritable microsystem for processing and transmitting information - in 1971 have made the electronics industry a top-level manufacturer whose productivity is constantly increasing. 1/ Every electronic system today contains transistors; extremely rare are the ones that do not yet incorporate integrated circuits; more and more systems are fitted with microprocessors and they will all have to have them well before the year 2000.

This trend has had two principal effects: the first relates to the system of coding the information to be processed or transmitted. The use of the analog method in computing techniques has given place to the digital method 2/ which demands a huge amount of elementary information - bits - which, moreover, make it possible to miniaturize the equipment: an integrated circuit of several square millimetres can contain more than a million bits. As a result, the use of systems to any extent complex results in the appearance of something new: the use of software. Indeed, with the former systems the analog technique used to make it necessary to establish electrical connections and controls for a given operation.

1/ See "Global Study on World Electronics" (ID/WG.478/2(SPEC.)).

2/ According to the digital technique, all information is expressed by a combination of as many items of elementary information as is necessary, the elementary information being in two possible states - symbolized 0 or 1 - as in the binary notation and becoming for that reason a bit (binary digit).

A change in operation could be produced, within limits, by altering the connections and the wiring. We then speak of wired logic. Today, the systems using millions of integrated components made of silicon can be permanently adapted to an operation - this is still the case with many of the mass consumer systems - but they may also be programmed, as only computers used to be, and be recontoured and adapted to performing other operations. This is programmable software which is gradually permeating all systems and at the same time guaranteeing the growing importance of software permitting such programming. Software, whose production is an intellectual activity involving design and coding, has become essential for any electronic system; it is therefore necessary to tackle together the issue of the electronics industry and that of the software.

The second effect, which is complementary to the first effect, is miniaturization. It has never stopped, bringing with it the use of new microelectronic components in all the systems made by the electronics industry and also permitting miniaturization - at least in the relative sense - of all the systems, together with a considerable reduction in costs. As a result, it is all these economic activities together which are called for. In effect, no activity can progress without the processing and transmitting of information; these are operations that used to be performed manually at a cost/efficiency ratio which as a general rule avoided any recourse to electronic systems, as being too expensive, too cumbersome and not very effective. The miniaturization effect, accompanied by a reduction in costs, has completely altered the picture and gradually changed all the activities; all machines tend to make use of electronic systems for processing and transmitting information and are thereby improved in productivity and quality. In this sense, the electronic technologies can be placed at the service of industrial development.

These considerations inevitably make the electronics and software industry one which plays a prime role in the functioning of the national production apparatus and it is clear that the developing countries must take into account the impact of the electronics industry on the process of industrialization and accord that industry the place it deserves.

At the present time, the status of the electronics and software industries is extremely different from one developing country to another. According to the country, production is larger or smaller and diversified. First, local resources in scientific and technological capacities may seem fairly well adapted to what is required by an industry which is all at the same time an assembly industry, a modern industry and an intellectual activity; secondly, the size of the country and its industry may offer a market with economies of scale which seem inadequate. However, whatever the position, all developing countries are confronted by the fact that the age of electronics has begun and that it governs the advances to be made in its production apparatus. The advances are tied in with its capacity to define, as a function of its own characteristics, the specific path that it follows to keep up with the electronic age, whether by rational use of electronic systems or/and the production of electronic goods suited to its internal market, and/or again by specialization in certain exportable electronic products.

To define this path it is, however, possible, as a function of the characteristics of the electronics and software industry, experience gained by certain developing countries and the strategies of the principal actors in world electronics, to find certain reference points for policies relating to electronic and software production and the benefits to be gained in that respect from co-operation at regional, interregional and international levels.

I. PLACE OF THE ELECTRONICS INDUSTRY IN THE WORLD

Forty years ago the electronics industry was almost non-existent. Although the transistor had just been invented, radio sets were still using valves, data processing was still in its cradle, and telecommunications were still the analog type. The only important market was that of the United States where, in 1946, 18,000 television sets were sold; 7 million sets were to be sold there annually by the beginning of the 1950s. In 1957 production of electronics in the principal countries with a market economy barely exceeded $12,000 million. Three quarters of that was accounted for by the United States, 5 per cent by Japan and the rest by the European countries, principally in mass consumer electronics and to a lesser extent in telecommunications. Between 1957 and 1982 the rate of development of world production was extremely steady: 13.3 per cent per year on average, with a speed-up starting from 1974: a yearly average of more than 16 per cent between 1974 and 1982. This is all the more remarkable in that the relative costs of information processing dropped 3/ and in that the trends in the world economy as a whole had, conversely, slowed down after 1974 (see table 1).

Table 1

Electronics production in the countries with a market economy
(in millions of dollars)

Year	USA	Japan	Europe a/	Rest of the world	Total
1957	9 200	500	2 700	400	12 800
1964	18 700	2 100	4 900	1 500	27 200
1974	38 900	13 200	29 700	6 000	87 800
1982	148 000	66 100	60 400	20 000	294 500
1987	185 000	148 000	140 000	87 000	560 000

Source: GERDIC (Study and Research Group for Development, Industrialization and Foreign Trade) based on different sources.

a/ 10 member countries of the European Economic Community.

Before the 1970s the share of the developing countries was virtually negligible. Local production consisted mainly in assembly operations for the benefit of local, relatively narrow, markets. Starting from the end of the 1980s, the relocation of enterprises of United States origin towards several of the South-East Asian countries brought about production intended for the domestic market. In the United States imports of semiconductors within this context attained $700 million in 1974 and three thousand million dollars in 1982.

The progress in electronics prior to the 1980s was made therefore in the industrialized countries. Japan maintained a growth rate higher than 20 per cent and its production (exported in increasing proportion, running from 30 per cent

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3/ In 1985 the cost of a memory bit was, in current value, 0.5 per cent of what it had been in 1970. This relates first to microelectronics and data processing (informatics). But the drop in cost is equally as marked in telecommunications or audio-visual devices: radios, tape recorders and television sets.

in 1973 to 50 per cent in 1982) overtook that of the European market economy countries at the beginning of the 1980s. Those countries made up for some of their backwardness in the United States between 1964 and 1974, though without exporting significantly and without their firms relocating to any great extent. Conversely, during that period the United States opened its economy, importing components and mass consumer electronics and exporting industrial electronics, above all data processing hardware. The United States had a growing surplus up to 1980, after which the balance receded and became negative in 1982. During the period 1974-1982, the electronics industry of the United States nevertheless developed very rapidly, as did its exports, which went partly to the countries of the European Economic Community, with which it has a strong surplus trade balance. The production of the EEC countries has in fact grown much more rapidly; starting from 1974, this area became a deficit area and the deficit did nothing but increase, except for trade in telecommunications equipment.

From the middle of the 1970s the investments by foreign firms, first, and the policies pursued by a certain number of developing countries in Latin America and Asia, second, started to make themselves felt and the proportion of electronic products manufactured in the developing countries was approximately 3.5 per cent of world production in 1974. That share rose quite considerably (it exceeded 5 per cent in 1982) because of the fact that a small group of South-East Asian countries recorded annual growth rates equal to or higher than 20 per cent of the production largely intended for export.

Since 1982, world production has continued to grow in value at a high rate (13 per cent on average) despite the slow-down in inflation, while the developing countries have been able to increase their share, thanks to China and India which have joined the previous group of fast developing countries. The share of the developing countries can be estimated at approximately 12 per cent for 1987; it should be close to 33 per cent for mass consumer electronics, but only 8 per cent for industrial electronics. (See table 2.)

Table 2

Production and world market per major area in 1987
(market economy countries)

	Production		Market	
	Thousand million dollars	In %	Thousand million dollars	In %
United States	185	33.0	204	36.4
Japan	148	26.4	97	17.2
Western Europe	140	25.0	160	28.6
Other industrialized countries	15	2.7	25	4.5
South-East Asian countries	44	7.9	30	5.4
Latin America	10	1.8	14	2.5
China/India	14	2.5	15	2.7
Rest of the world (except countries with a planned economy)	4	1.7	15	2.7
Total	560	100	560	100

Source: Estimates by GERDIC (based on various sources, more especially the Elsevier Yearbook of World Electronics Data, EIAJ (Electronics Industry Association of Japan) and the professional press.

Trade in electronic products occupies an increasing place in world trade, although the relative cost of these products has dropped. The proportion of them rose accordingly from 4 per cent of world trade in the 1970s to 7.3 per cent in 1986. Their share of the trade in manufactured products attained 11.5 per cent in 1986: the figures for trade in electronics are thus higher than the combined trade figures for textiles and clothing; 4/ it is equivalent to three quarters of the world automobile trade.

The remarkable upswing in this trade is due to both the dynamics of the world demand for these products and to effects, first, of specialization in certain national economies and, second, of international splitting up of production processes by the larger firms. As far as data processing is concerned, we have to add to these causes the considerable transformation undergone by this industry with the great strides made in micro-data processing, which has enabled a real explosion in demand to occur.

Table 3

Share of electronics in world trade

	1967	1973	1979	1984	1986	
	(in %)				in thousand million dollars	
Electronics	3.0	4.0	3.8	6.1	7.3	154
Components	0.3	0.7	0.7	1.4	1.2	26
Mass production	0.7	1.1	0.9	1.2	1.3	27
Telecommunications	0.1	0.9	0.9	1.2	1.4	30
Data processing	1.1	1.3	1.3	2.3	2.6	55
Industrial electronics	n.d.*	n.d.*	n.d.*	n.d.*	0.8	16

* n.d. = no data available.

Source: CHELEM data base from CEPII, except for 1986: data from GATT (report for 1986-1987).

Electronics is an industry the weight of which has considerably grown within the advanced economies. The ratio between the value of sales of electronic products and the value added in manufacturing (VAM) has almost tripled in the economies of the larger industrial countries since 1960. (See table 4.) This shows a strong structural modification in favour of the electronics industry.

4/ Data from GATT (1986-1987 report).

Table 4

Ratio between electronics sales and VAM in some of the market economy countries

	1960			1985		
	Sales of electronic product	VAM	Ratio in %	Sales of electronic product	VAM	Ratio in %
Federal Republic of Germany	1 117	28 828	3.8	17 837.8	236 403	7.6
United States	12 709	145 841	8.7	178 096.6	683 865	24.9
France	716	18 016	3.9	11 706.0	129 079	9.1
Japan	1 196	14 212	8.4	50 636.5	347 251	14.6
United Kingdom	1 437	23 072	6.2	13 724.3	82 139	16.7
Total	17 174	229 969	7.5	272 001	1 477 737	18.4

Source: Taken from M. Humbert, "Industrialization strategies in electronics", Rennes, GERDIC (1988).

As can be seen from table 4, this structural transformation has been much more clear cut in the United States and in Japan. Indeed, in the United States between 1972 and 1986, employment in the electronics industry doubled, rising from 1 million persons to 2 million, or in percentage of factory employment, from barely 5 per cent to more than 10 per cent. While factory jobs stagnated to the benefit of services and while unemployment affected most of the manufacturing activities, the electronics industry took on a considerable amount of manpower. In Japan, employment in the electronics industries grew by 50 per cent between 1980 and 1986, whereas factory employment rose very slightly (less than 1 per cent per year). In consequence, the share of electronics in factory employment - higher than that of the automobile industry since the end of the 1960s - rose from 7.9 per cent in 1980 to 11.1 per cent in 1986. These examples show the increasing role played by electronics in the economies of the most industrialized countries.

II. THE CONTRASTING PERFORMANCES OF THE DEVELOPING COUNTRIES IN THE ELECTRONICS INDUSTRY

As long as the electronics industry maintained a modest place in production and world trade, the developing countries were not encouraged to promote electronics production on their own territory, where it remained marginal. Two trends have been responsible for the first measures, aimed at starting the development of electronics production. The first is the appearance of telediffusion systems in the countries with a potentially vast internal market: it led to mass consumer electronics around 1960, especially in the larger countries of

Latin America (Argentina, Brazil, Mexico etc.) and Asia (China, India). The second, at the end of the 1960s, was a search for more attractive conditions for the cost of manpower by the multinational firms, mainly originating from the United States, ready to relocate the more intensive stages in the production process, more especially for components, and the opportunity which was seized in that respect by several countries of South-East Asia (Republic of Korea, Singapore, Hong Kong and Taiwan), followed by others in the 1970s.

The first trend therefore involves the development of production destined basically for the internal market and in most of these countries fits into the framework of an import substitution policy. It is chiefly made up of mass consumer electronics, in which the television set is the most important article. In Argentina, India and China the black and white television manufacturers will be basically local enterprises, but with the advent of colour television in the 1980s, these countries will in one way or another turn to foreign firms. In Mexico and in Brazil, foreign enterprise has been considerable since the very beginning and the public authorities have had to take action to stimulate local integration, more especially for the manufacture of tubes. None of these countries has developed a learning process adequate to place the national industry on a footing where it can keep up, of its own accord with the transformation of the electronics industry (digitization and miniaturization). The technological change alone by which black and white television moved on to becoming coloured required recourse to countries abroad. It seems that apart from the rather limited resources which different countries could devote to this area the content of the industrialization policies was not such to encourage them to show technological dynamism.

Starting from the middle of the 1970s, all the above-mentioned countries took action to promote the development of the electronics industry, chiefly data processing, and started up programmes for developing the telecommunication infrastructures. Telecommunication programmes are generally speaking implemented by large multinational firms with whom countries seek to negotiate contracts for local assembly operations and a little bit of integration. The upswing of the data processing industry, conversely, is conceived from the standpoint of an import substitution policy by the former group of countries with a fairly extensive internal market and with the desire, at least as far as the smaller systems are concerned, to promote solely local producers. 5/

The countries which started their electronics production on the occasion of the international relocations have followed quite a different path. The first group of countries (Hong Kong, Republic of Korea, Singapore and Taiwan) managed to broaden their field further than just relocated production. They combined their initial export-based activities with other activities in mass consumer electronics in order to take advantage of some of the simple components exclusively exported until then. Mass consumer electronics production, which is itself intended for export, was gradually carried out with more advanced local integration within the branches of foreign firms, joint enterprises, and local firms and with a great deal

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5/ Brazil and India have initially reserved the production of microprocessing for local firms so as to develop their own technological capacities; they have also promoted the local construction of electronics centres.

of subcontracting by equipment manufacturers (original equipment manufacturer). The more sophisticated components of mass consumer electronics, colour tubes and even the integrated circuits of microelectronics were soon being produced, chiefly in the Republic of Korea and Taiwan, thanks to the activity of the State and local groupings. These manufacturers then showed themselves capable of moving on from television tubes to monitors for microcomputers, for which they also developed the production of peripherals. It is worth noting that the first personal computer sold by IBM consisted by more than a third of parts and components made in South-East Asia. The spectacular progress in this field has raised the Republic of Korea to the rank of sixth world electronics manufacturer within 15 years; the production of electronics, which represented 2 per cent of national production in 1970, today constitutes more than 10 per cent. The Republic of Korea recognizes, however, that it will have to make further headway if it is to acquire technical and industrial know-how in data processing and telecommunications.

A second group of South-East Asian countries (Malaysia, Philippines and Thailand) seems to have difficulties in following in the footsteps of the Republic of Korea. It should nevertheless be noted that Malaysia, with a trade surplus in electronics, is engaging in more complex stages than assembly (component testing and silicon foundries); that Thailand is seeking to increase the integration of its mass consumer electronics by taking up the manufacture of television tubes. In a very general manner, all of these countries are in a position to benefit from a new wave of relocation of enterprises originating from Japan, though also from other countries in East Asia. This movement should help them to develop an electronics industry within the framework of a strategy combining export, subcontracting, growing integration and protection of the local market.

Other attempts may have been made by different countries in this, that or the other direction in, but neither the attempts, nor their results have been reported in the literature on industrial development.

III. THE STRATEGIES OF THE PRINCIPAL ACTORS IN WORLD ELECTRONICS

The strategies of the public authorities, together with those of the larger firms, which are often international, have helped to shape the world electronics situation.

A. Strategies of the public authorities

1. Industrialized countries

The public authorities of the industrialized countries have played an important part in the electronics industry since its beginning for a variety of reasons linked to sovereignty, assessment of the technological impact of the industry and the foreign trade situation.

The various activities pursued by the public authorities can be classified in two major categories, according to whether they are geared more directly to organization of the supply or organization of the demand.

(a) Organization of the supply

Among such activities we can quote the development of training branches (technicians and engineers) and national, and even multilateral, research funding

(ESPRIT European programme). These measures also concern the industry more directly and, in addition to the assistance and subsidies, they may be instrumental in encouraging restructuring (case of data processing in Europe) and to controlling foreign investments.

(b) Organization of the demand

The most frequent practice has been to ensure national outlets for the manufacturers of telecommunications equipment or data processing equipment. Several States have also endeavoured to organize the diffusion of competitive products among consumers or enterprises and administrations.

In certain countries these strategies, by means of these different approaches, have tended to create a coherent and efficient apparatus for electronics production without always succeeding in doing so in an entirely satisfactory manner since many of the firms and industries in difficulties still have to be helped.

2. Developing countries

In the developing countries the industrial policies relating more directly to the electronics industry have often given priority to objectives such as gains in foreign currency (import substitution or promotion of export) and the creation of employment; they have less often taken into account the technological impact of this new industry and have only in exceptional cases broached it with consideration for all its component parts. (It should be noted that mass consumer electronics does not come under the same ministerial departments as the component sector, nor do telecommunications and data processing.)

The Republic of Korea is number six in the world in terms of its electronics production (in value). The upswing of the electronics industry there has been partly due to action by the State. The first decision on industrial policy relating to electronics was adopted in 1966 (training in electronic techniques). Among the set of decisions adopted since then we can quote: the Electronics Industry Promotion Law, which recognizes the vocation of that industry as an exporter and provides also for the establishment of the Gumi industrial area open only to electronics enterprises (it is not a free zone); the different sections on electronics in the Industrial Plans (1972-1976: priority for mass consumer electronics and discrete components; 1977-1981: priority for equipment; 1982-1986: priority for highly integrated circuits and data processing). Among the more direct action we could recall the launching of State enterprises (telecommunications) and research centres in the 1970s, these efforts being later taken over by the private sector.

Brazil is one of the most important manufacturers of electronic products in the developing countries. Initially the Brazilian industrial policy related more to finished products, whether producers' goods or durable consumer goods, produced mostly in the Manaus free zone. From 1979 onwards, to make allowance for the strong interrelationship existing between the different subsectors, the Secretariat for Informatics (SEI) saw that its mission should be extended to cover, apart from data processing, automated equipment and microelectronics. SEI's objective was to promote national capability in designing and constructing integrated circuits. The intervention of the State in the area of data processing was quite considerable from 1977 onwards. The Government pursued a policy of "reserved markets", reserving for local enterprises alone the possibility of making micro- and mini-data processing equipment. In 1984 a data processing law limited access by

this industry for a period of eight years. That context has furthered the development of a national industry.

B. The strategies of the firms

The electronics and software industry is an industry of world importance in the sense that a number of large groups originating from industrialized countries - though some groups originating from developing countries have joined them - are developing their strategies at planetary level and possess production facilities in a large number of countries. Several production segments are dominated by a small number of actors: the larger telecommunication centres, the major data processing systems, semiconductors, colour television receivers, video recorders, microprocessors, work stations, and the key software for microcomputers (spreadsheets, data bases, text processing), to name a few. These multiple oligopolistic markets in which a part is played, among others, by firms specializing in a single market segment, are controlled by a larger oligopoly that is dominated by groups often participating in a large number of segments and attaining a considerable turnover: the first 10 world groups are responsible for almost a third of the world electronics sales. This is far less than in the case of motorcars, but there the range of products offered is much broader.

The strategies of the new entrants or firms of modest size are obviously forced to make allowance for this density and power exercized by a few leading firms on each well-defined market. As a consequence, they seek a niche in the market unoccupied by the leaders where competition is less strong, first and foremost, on account of the modest size of the market segment, which has not (yet) attracted the bigger operators.

The strategies of these main operators have developed very little during the 1980s under pressure from added competition linked, first, to the deepening of the technological development, which unified the domain, and, second, to the rise in power of the principal Japanese groups and the advent of new groups from different countries, including developing countries such as the Republic of Korea. The first characteristic of this trend is the search for greater versatility, permitting the group, first, to have a more flexible and uniform internal organization where the growth in productivity is associated with the unfolding of an active human resource; second, it is a matter of thus being capable of reacting promptly to a fluid external environment. This characteristic is the one which has made possible the other changes observed in the strategies of these groups.

In their choice of areas of production the principal groups have abandoned the strategies of diversification and coverage of the entire range of products of the electronics and software industry. For example, IBM, having launched into telecommunications when the centres became digital, has withdrawn. In France, Thomson has recentred on a few new directions although the public authorities had encouraged it to cover a large number of areas. This recentring strategy - which can also be perceived in other industries - is connected with the need to keep within different segments a big enough part of the world market for production on a competitive basis. It is combined in electronics with a desire for vertical integration: profits seem to be made with systems for which the group has the know-how, with the provision that enough of the world market has been retained, but to some extent the know-how is linked to certain essential components, i.e. certain building bricks. Hence all of the electronics manufacturers want to make a minimum number of these components.

The selection of installation sites abroad is no longer associated predominantly with a search for lower salary costs. First and foremost, the point is to exploit the advantages of the group in the fields that it has mastered, at world level, consideration being given to a set of conditions, more especially the local capabilities of markets and the flow of trade. Component firms in the United States may still seek to set themselves up in South-East Asia, but more perhaps for reasons associated with the capabilities and markets to be found there. Japanese firms are going all out in their investments abroad since they have exhausted possibilities for further international expansion solely on the basis of exports and because they feel that they can produce competitively both in the United States and in Europe. They also seem to be turning towards intensive relocation and investment in nearby South-East Asia and China. Some Korean firms have recently undertaken a similar relocation dynamic.

Finally, the desire to control the environment now proceeds by way of increasing the foreign relations of the groups in completely new forms, which differ considerably from the cartels of the past. The most spectacular result of this is clearly the weaving of a dense fabric of world alliances based on bilateral and multilateral agreements with consortia which may themselves be sponsored by the public authorities of one or more nations. This is the case with SEMATECH in the United States and one could also quote the EUREKA projects, such as JESSI for which Philips, Siemens, Thomson-SGS and Plessey are joining up with many other firms and obtaining public funds from six European countries to prepare for the electronic components of the future. These alliances prepare for the future, but also organize the present in a frequently more traditional manner by regroupings and mergers which reinforce some of the groups in the directions chosen for their recentring. Thus Thomson, the French group which has engaged in a joint venture with SGS ATES (Italy) for its component line; Hewlett-Packard, which has brought back APOLLO for the work stations (United States), CIT Alcatel (France), which has repurchased activities in telecommunications outside the United States, principally European ITT, and so on. To the co-operation in research and development, to the mergers and joint ventures for market segments, in order to penetrate certain territories, we can add the traditional subcontracting relationships for the supply of intermediate products, though also the OEM (original equipment manufacturing) agreements, or those involving a second source in the case of finished products. The increase in these co-operative relationships does not hinder rivalry and firms usually like to have real competition. In this sense, they show that they are especially keen to see common world standards accepted, at least after failing in their attempts to have their own accepted. Hence there are battles in progress over the standards for future high-definition television, future microcomputers and future software permitting the interlinking or interoperability of data processing systems.

IV. MAIN POINTS TO BE TAKEN INTO ACCOUNT IN DEFINING AN INTEGRATED DEVELOPMENT STRATEGY FOR THE ELECTRONICS INDUSTRY INCLUDING SOFTWARE

In order to define a development strategy for the electronics industry, we have to bear a number of points in mind. First, we have to see what place this industry occupies in the national economy. Then we have to consider, first, the principal features of the markets in terms of their different products and, second, the resources available to the country for local production. There are many elements there which enable us - and that is the main thing - to guide the search for coherence in the production apparatus. This should be done by stressing co-operation on a regional, interregional and international basis.

A. Integration of the electronics industry into the national economy

Now that industry as a whole is going in for electronics, a country cannot disregard its national economy if it wishes to ensure industrialization. However, it is not just a matter of launching into the production of certain electronic systems without going through the selection of them as a function of different criteria. Furthermore, the introduction of electronics into the strategy of industrialization leads us to reconsider the former at the time when it was organized around other industries. We should therefore undertake a reorientation of the industrial policy and a reallocation of the resources. Finally, integration of the electronics industry should make allowance for the problems of the foreign constraint.

In many countries the trade deficit in this sector is considerable. As a result, most countries contemplate local manufacture in order to replace the import of certain vital products, or even to export them in order to loosen the constraints on the balance of payments and the foreign debt.

B. The different electronics markets

The characteristics of the different markets may explain the choice of a development strategy for the electronics industry. We can draw a distinction, in particular, between the markets for telecommunications, data processing, industrial automation, mass consumer electronics, components and software.

In telecommunications the most open market is the terminal equipment market which offers extensive opportunities. The manufacturers physically close to the networks to which these terminals should be connected posses an advantage. The advantage will be weakened if there is generalization of the national deregulation in the area in the interests of international standardization. If the major centres continue to be designed by world groups able to invest considerable sums in research and development, it will still be possible to undertake assembly operations locally with a certain degree of national integration prior to setting them up. Furthermore, the smaller private centres are less demanding in nature.

In data processing, the most dynamic segment is that of microprocessing, which is also very often a considerable item of import in the absence of national production. The size of the national demand is such that many countries are led to wonder whether there should not be micro-data processing for the microcomputers themselves and for their peripherals. This is one of the areas in which the final assembly of count key data devices (CKD) is practised.

Industrial automation systems represent an extremely dynamic market, but one which is made up of products that are usually of great technological complexity. Nevertheless, the software is relatively important and we begin to see the advent of industrial orders for simple software operating on the basis of a microcomputer.

Mass consumer electronics is another area where the absence of national production and control of imports causes a high foreign deficit. As a result, a large number of countries wonder whether there should not be local production of at least some products or certain production stages, while not wishing to stay indefinitely with just the assembly of kits.

The production of components remains an extremely dynamic sector which still employs a relatively large amount of manpower, even though the technological trend

has brought more and more automation, as for example in the manufacture of printed circuits (and the surface-mounted components (SMC) technology). This sector serves all the other electronics sectors and after an initial stage of production by replacing the import of finished products, it will have to take up the manufacture of sub-assemblies or components. Beside the sophisticated components, there are still the more traditional discrete components, which perhaps form more accessible markets.

The software market is one which is growing very quickly and in which the proportion of independent manufacturers has risen at the expense of equipment manufacturers, principally in data processing. In software for special use, there is clearly a place for local production intended for local users, since the proximity of the two parties facilitates the continuous relationship that they have to maintain. Entering into the production of the larger and more general software, on the other hand, may create difficult problems. Furthermore, we should also note here a certain tendency towards automation of software writing.

C. Local production and technological resources

The principal question is to evaluate the resources properly, especially the technological resources, which are necessary for the development of local production. We can draw a distinction for this purpose between five modalities.

The first modality is utilization; in a large number of cases it is not as simple as it seems and is another issue to be discussed at this meeting, namely how to place the electronic technologies at the service of industrial development.

The second modality is in actual fact an extension of the first one. It relates to the production of applied software. The production of software is the production of resources for using hardware, data processing equipment as a whole. Production takes place most often at the site of a client who has equipment to be used or by means of telecommunication with the client. This therefore presupposes in the case of local production clients with equipment and, in the direct sense, with the intellectual capability of designing and writing software, which is a high-level qualification (engineers and senior technicians), as well as, sometimes, good infrastructure for liaison with the international telecommunication networks.

The third modality, which is that of the assembly of systems, presents fairly extensive accessibility, but is not immediately available except for certain manufacturers. The other aspect of this broad accessibility is obviously the low level of technological learning possible by way of such activities when they are reduced merely to assembly. It nevertheless enables us to meet certain requirements of local manufacture.

The fourth modality is the introduction of a production process as complete as possible. It is all the more demanding in terms of technological capabilities in that we wish to return to the upstream stages of the production process for the more general case. For sophisticated components or systems, the downstream stages of testing and liaising with clients are equally stages which require costly equipment and very high-level qualifications. For most countries and most segments, it is normally only possible to operate at an intermediate stage of this modality. The fifth modality is accessible only with mastery of the totality of a production process for a particular product that it is then wished to advance. This clearly requires a great deal of expenditure on research and on keeping up with the status of world technology. Few developing countries have a chance to

face this problem, but such might be the case, directly or indirectly, with certain segments of the micro-data processing or mass consumer electronics.

To enable the electronics industry to take its desired place in the national economy, we certainly have to bear in mind the realities of national potential in face of constraints on the technological modalities and the market characteristics, but above all we must put into effect measures aimed at seeking the coherence of the production apparatus.

D. The search for consistency in the production apparatus

A major snag in any industrialization policy is the setting up of a series of factories that operate virtually without any interrelationship and thereby miss the entire potential synergy that careful selection and certain political-economic measures might have been able to create. Starting with thoughts on the resources that it has available for promoting local electronics production, a developing country will have, on the other hand, the problem of developing an internal dynamic by assigning priorities which permit synergic relationships and create learning effects.

If they have started by using or assembling electronic systems, the countries will seek to improve gradually the level of national integration and will facilitate the establishment of complementary types of production. To avoid the misuse of protection, which cuts through the world realities at the expense of both chances of dynamic learning by the manufacturers and services offered to the users, especially when they are industrialists, there will be need to establish selective and graded protection.

The action adopted will have to be based on a longer set of problems devised by the public authorites who have to create an environment favourable to the creation of this dynamic: support for training and retraining of personnel, encouragement of foreign branches to involve themselves in the local industrial fabric and in the upswing of its technico-industrial capabilities.

Beyond that, it is possible that the State should not only encourage the initiatives of smaller production units and those of commercial enterprises geared to assembly, but also foster the formation and reconversion of private and public national groups which may exist in other sectors, so as to set up enterprises of the minimal size required by certain markets.

Finally, the public authorities will have to examine all the regulatory measures governing investment, licences and patents as well as the transfer of technology less by recourse to the rigid and exclusive principles of import substitution or export promotion than by their potential effect on the internal dynamic by which to build up a territorial production system composed of production units and to ensure that they maintain a large number of synergy-containing relationships.

E. Regional and interregional co-operation

In most branches of industry the advantage of regional and interregional co-operation has already been given broad emphasis; such co-operation is also necessary in electronics. The European countries are showing in their own way that it is in fact a sector where such is vital.

Extensive regional co-operation is already under way, for example between the countries of Latin America where several networks - some of them sponsored by UNIDO - such as REMLAC (Micro-electronic Systems for Latin America and the Caribbean), already make it possible to exchange information and keep abreast of the advanced electronic technologies. We can also note in this region the meeting on micro-electronics organized under the auspices of the Organization of American States (OAS) in October 1988, or certain projects such as BRAMEXVEN between Brazil, Mexico and Venezuela, which envisage the design of a microprocessor using their own technology by the research institutions of those countries.

This co-operation should deal not only with the research aspects but also, and more importantly, with industrial action for better use of local resources and utilization of complementarities. The intrazonal investments of South Asia are an example of one of the ways for such regional co-operation, which could rise above the formation of regional groups if the latter could be made aware of the complementarities existing on a broader scale, if only for setting up industrial and technological information networks. The latter could even be introduced at a broader level.

F. International co-operation and technological development

The present state of world technology which is such that the commodities of the electronics industry can be manufactured under the best competitive conditions is available to the countries and companies most active in the field. This is partly due to knowledge which is in the public domain, provided one has access to data bases where it is recorded or to publications in which it appears. The developing countries can expect international co-operation to provide them with easier access to all information. They will then be in a better position to negotiate, in a spirit of mutual trust, the terms for transfer of know-how protected by patents and licences, which is usually necessary when starting new manufacturing processes under favourable conditions. They will also be in a better position to master officially transferred technologies, provided the accompanying programmes for scientific and technical co-operation bring personnel into more direct contact with the industrial realities from which these technologies stem and enable them in this way to gain all the potential advantages.

Finally, the developing countries are undoubtedly hoping to join in the process of standardization at world level of a number of electronic systems, which will guarantee the opening up of them and at the same time a chance of not being dependant on a small number of manufacturers forming a closed shop, and of stabilizing less oligopolistic competition, which will make it less difficult for new manufacturers to have entrée.

Understood in this manner, international co-operation could facilitate industrial and technological development.

V. FINAL CONSIDERATIONS

The world electronics industry including software presents an extremely important evolutionary dynamic which stems in essence from the strategies of the public and private actors in the industrialized countries. This evolution, the characteristics of which have been recalled above, demands all the more attention in order to define in the developing countries an integrated development strategy for the electronics industry including software.

Bearing in mind the observations made in this report, it seems vital that this meeting should discuss the following points so as to arrive at its conclusions and recommendations:

The place of the electronics industry in the national economy

- The share of developing countries in the world production of the electronics industry is modest (of the order of 12 per cent) and distributed over the countries very unequally, since their performances in this sector are very different;

- No country can remain apart from this industry, the technological progress of which is permeating into branches of industry;

- The introduction of electronics into industrialization strategy should be made in a selective manner in each country, bearing in mind the following factors: technological level, market size, external constraints;

- Consideration of the industrial restructuring to which the introduction of electronics has given impetus at world level could lead to reorientation of the strategies if they have been organized around the branches most affected by these developments (clothing, machine-building, machine tools).

Entry into the electronics industry

Entry into the electronics industry should be made in a selective manner, though without losing sight of the linkage between the different subsectors. Among the factors to be given consideration are:

- Technology: choice of a technologically simple point of departure or one more centred on a precise production area around which more complex activities can be attached;

- The characteristics inherent in the different markets with distinction in particular between the markets for telecommunications, industrial automation, mass consumer electronics, components and software;

Among the possible points of entry are:

- Telecommunications, where assembly operations are envisagable for telephone exchanges, especially small private exchanges, and for terminal equipment. These are operations that require little in terms of market size and technology;

- Data processing (informatics), where one can assemble CKD devices for manufacturing microcomputers and peripherals (disk readers in particular) for the local market;

- Mass consumer electronics, where national production in the form of assembly is possible in the case of audio and video products. More intense integration may come up against problems of scale in the case of video devices (minimal market of 1 or 2 million for television tubes). Entry into the international market is then a means of broadening the market for intermediate products so as to ensure greater integration; this entry can be achieved by subcontracting or under OEM agreements in an ever-growing number in the case of audio and video products;

- Encapsulation of integrated circuits such as memories is an activity that is still only slightly automated. Conversely, the manufacture of these components belongs to a highly complex technological domain which demands access to very large-size markets; the manufacture of other circuits such as applied specific integrated circuits (ASIC) can be contemplated for narrower markets, but requires, too, a high level of technicality. Discrete components which are more traditional are a more accessible activity both from the standpoint of technology and access to markets;

- The production of applied software intended for local users may be a path of entry into the industry in the same way as the maintenance of equipment, especially in smaller countries. The concept of ASIC is also to be envisaged, since they can be manufactured in foreign foundries.

Generally speaking, the multiplicity of products in the electronics industry favours the strategy of seeking market niches which are not occupied or have been relinquished by the leading countries at world level.

Action to be taken to promote and accompany the development of the electronics industry

- Industrial policies should take into account the ever-growing technological interrelationships between the different subsectors of that industry. It would be advisable for the organization of departments looking after that industry to be conceived in terms of such interrelationships;

- Choices of an import substitution policy or export promotion policy should not be mutually exclusive. Conversely, both policies should be conceived in terms of more coherent research;

- Protection of the national electronics industry should be selective and graded.

Industrial policies should aim at improved organization of what is supplied by the electronics industry by taking measures to promote:

- The development of training branches linked to electronic technologies;

- The retraining of personnel who should adapt themselves to the new technologies;

- The improvement of infrastructures (in particular telecommunications).

In certain cases the State will have to encourage the formation and reconversion of private and public national groups so as to create enterprises of the minimal size required by certain markets (that may also be the case in the manufacture of television tubes or the construction of silicon foundries).

Regulatory measures governing investment, licensing and patenting should be conceived in terms of their effects on the dynamics of that industry and on the search for greater coherence.

Modalities for regional and interregional co-operation

Among the modalities for co-operation envisaged are:

- Co-operation programmes for improved dissemination of technological information between countries;

- Co-operation programmes at the level of training in electronic technologies;

- Scientific co-operation programmes to promote research and development efforts;

- Industrial co-operation activities for the introduction of complementarities or for broadening the market constraint (for example, study of silicon foundries conceived at regional level);

International co-operation

Among the areas in which international co-operation can be applied are:

- Technological information: facility at the diffusional level as well as access to data bases;

- Standardization: the developing countries should join in the standardization processes;

- Scientific and technical research by increasing the possibility of training courses by which to permit more direct contact with industrial realities.

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Prepared by the Secretariat of UNIDO

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Explanatory notes

Unless otherwise indicated, the dollar sign ($) means the United States dollar.

The following initials have been used in this report:

CAD	Computer-aided design
EEC	European Economic Community
MIT	Massachusetts Institute of Technology
NCMT	Numerically-controlled machine tool
OECD	Organization for Economic Co-operation and Development

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INTRODUCTION

The rise of electronics technologies marks the birth of a new industrial age. Ever less expensive, ever more compact and ever faster-operating electronics systems are being used at all stages of goods and services production.

The electronics systems forming the subject of this document are those involved in industrial development: computerization, specialized electronic equipment, electronic components and software. In addition, although services play a significant role in the economy, and the use and extension of computerization, both in public services and in banks, etc. represent very important phenomena, the present study will pay particular attention to the diffusion of these systems in industry.

An evaluation will be made first of the degree of penetration of electronics technologies in industry and then of the implications thereof for certain industries of special importance for industrial growth in the developing countries. This will make is possible to identify the various aspects to be taken into consideration when placing electronics technologies at the service of industrial development.

I. PENETRATION OF ELECTRONICS TECHNOLOGIES IN INDUSTRY

In the absence of more or less precise data on the incidence of various electronics systems in a group of industries with varying levels of development, reference must be made to more general or more specific studies in order to gain an idea of the degree of penetration of electronics technologies in industry.

In a general manner, use can be made for example of a study by the Organization for Economic Co-operation and Development (OECD), 1/ where it is stated that "since the mid-1970s and until 1985 ..., the internal demand (in OECD countries) for information technologies 2/ registered a growth in real terms of about 6 per cent per year, thus more than twice the mean growth rate for overall industrial production". According to the same document, the proportion of electronics technologies in the internal demand for manufactured goods increased from 5.5 per cent in 1975 to 7.4 per cent in 1983, compared with 9 per cent in connection with the demand for products of the automobile industry. Japan and the United States are the most advanced OECD countries and with them this proportion was, in 1983, 8 and 9 per cent respectively. These figures show the overall significance of the use of electronics technologies in the economy and the rapid growth of this use.

With more specific reference to the penetration of these techniques in industry in general, the OECD study in question gives, for a number of countries, an estimate of the demand by enterprises for information technologies as a proportion of gross fixed capital formation (see table 1: unfortunately there are no comparable statistical data available for the developing countries).

Table 1

The share of investment in information technologies in gross fixed capital formation for a number of countries
(in per cent)

	1984	1987
Germany, Federal Republic of	11.6	13.5
United States	14.6	18.1
France	9.0	9.7
Italy	8.8	10.6
Japan	6.9	8.3
United Kingdom	15.0	16.7

Source: OECD, Science and Technology Policy Outlook (Paris, 1988), pp. 105-106 (of the French text).

1/ Organization for Economic Co-operation and Development (OECD), Science and Technology Policy Outlook (Paris, 1988).

2/ The OECD and also the European Economic Community (EEC) have adopted the term "information technologies" for designating what is here defined as "electronics technologies".

These figures indicate powerful and dynamic penetration. Another study, in fairly general terms and dealing only with the United States, 3/ shows the trend since 1950 on the basis of data in constant 1982 dollars in the share accounted for by electronics systems in total new investments in capital goods and plant. This share increased from 7 per cent in 1950 to 10 per cent in 1960. It reached 20 per cent in 1978 and was more than 40 per cent in 1984. The reference here is to investments made by all producers of goods and services and this figure corresponds, in particular, to the important feature, already mentioned, of the significant degree of computerization of services. This is of direct concern to industry, having recourse to numerous external services, and its own activities, within enterprises, calling for services involving commercial management, personnel management, production management and so on.

More detailed information 4/ on the penetration of electronics into the industry of three European countries - the Federal Republic of Germany, France and, in particular, the United Kingdom - makes possible a somewhat better localization of the sites and intensity of this penetration. The information given relates to two forms of penetration: the introduction of microelectronics into the products themselves and the use of electronics systems in the production processes. Between 40 and 50 per cent of the industrial undertakings in these three countries were using microelectronics in one form or another in 1984. All industrial sectors were affected to roughly the same extent, including the clothing and textiles sectors. There is, however, a difference that should be noted: with the exception of the engineering, the electrical and electronics, and the automobile sectors, there is virtually no introduction of electronics into the actual products. This of course follows from their nature: the time has not yet come when food commodities or the metal industry is stuffed with electronics.

The study on the United Kingdom 5/ gives an idea of the recent trend in this penetration. In 1978, hardly 7 per cent of United Kingdom enterprises were using microelectronics, while in 1987 the proportion was two thirds. As regards the sectoral distribution in terms of the two types of penetration, the same remarks apply, although the differences between the intensity of penetration into processes are reduced depending on the sector concerned. In enterprises introducing microelectronics into their output, 70 per cent use market microprocessors, while 18 per cent use integrated circuits made to order and 11 per cent pre-diffused circuits. Of the electronics systems introduced by undertakings into their production processes, programable automata are the most numerous: nearly 30 per cent of all industrial undertakings in the United Kingdom use them (i.e. about

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3/ "Technology and the American economic transition - choices for the future", Washington, GPD (OTAT, 1988), p. 16.

4/ The data are drawn from two studies: the first, published in 1985, concerns three European countries with respect to the years 1982 to 1984 (J. Northcott et al., "Microelectronics in industry: an international comparison: Britain, Germany, France" (January 1985, PSI-AGF)). The second study covers only the United Kingdom but provides data for 1987 (J. Northcott and A. Walling, "The impact of microelectronics" (PSI, 1988)).

5/ The United Kingdom data used describe a situation which doubtless approximates to that of the majority of market-economy industrialized countries.

110,000 automata). Slightly less than 30 per cent have recourse to CAD work stations. On the other hand, there is only one production unit in five which uses NCMTs (i.e. a total of about 42,000 units), and only 2 or 3 per cent of undertakings possess robots or manipulators.

The above figures highlight the extensive diffusion of electronics in all activities undertaken in the advanced countries, including industrial activities, even though factory workshops are still only rarely entirely automated. 6/ On the other hand, the few data available suggest that the penetration of electronics technologies in industry in the developing countries is much less strong. While some of those countries register a pronounced deficit in the marketing of electronic products, this is most frequently due to the impact of electronics for the man in the street or of computerization for government and other services. Thus it is rather those countries with "excess" electronics which have already introduced these technologies, for, as we have just seen in the case of the United Kingdom, electronics production is itself a significant employer of electronics techniques.

However to the extent, at world level, that the majority of industrial activities tend to make use of these technologies, the developing countries are affected by this use in connection with their industrial expansion, and should study the implications of this penetration by electronics techniques.

II. THE IMPLICATIONS OF THE INTRODUCTION OF ELECTRONICS TECHNOLOGIES IN CERTAIN SECTORS

In the light of the foregoing remarks, attention should be given to the implications of the introduction of electronics technologies in sectors characterized either by the use of electronics in production processes or by the introduction of electronics into products.

As regards the first category - since all sectors are now affected, at least in the advanced countries - it is important to choose those sectors of significance for the majority of developing countries, a significance associated with the position of the sector in question in the industrial structure of the country and in its foreign trade and which might be jeopardized without the use of electronics technologies. The textile and clothing industries would appear to meet this criterion. Since the developing countries are at present enjoying a relatively more favourable situation on the world market for clothing than on that for textiles, while the penetration of electronics has remained less intense in the case of clothing, this latter sector represents the most important field in terms of the potential implications of the introduction of electronics technologies for the developing countries.

The second category comprises in the main the electrical and electronics industry, the motor industry and the mechanical engineering industry. The electrical and electronics industry forms the subject of another issue at the present meeting (strategies for integrated development of the electronics industry

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6/ The number of workshops of this type known as "flexible shops" throughout the world was estimated at 350 in 1985 in a study by the Economic Commission for Europe (New York, 1986, pp. 29 and 42). Even assuming a very high rate of growth, this number is not likely to be more than 1,000 today.

including software). The automobile industry is an industry producing in the first instance consumer goods supplemented to some extent by industrial vehicles, whose importance in terms of capital goods production does not approach that of the mechanical engineering industry. To varying degrees, the latter affects virtually all the developing countries and hence all industrial activities. After considering the clothing industry, therefore, we shall turn to the mechanical engineering industry.

A. The clothing industry

The clothing industry is fairly internationalized with numerous interactions with other countries and substantial injections of foreign capital. In terms of their share of world production, the developing countries went from 8 per cent in 1953 to 25 per cent in 1975, 7/ a share which appears to have stabilized since. The share of the developing countries in world exports reaches nearly 50 per cent and represents more than 8 per cent of the total value of their own exports, or 14 per cent of their exports of manufactured goods. 8/ This shows the significance of this branch for industrial development.

In order to understand the problems associated with the introduction of electronics technologies into this industry, it is necessary to have an idea of the main characteristics of the production processes current in the clothing industry. Four stages can here be distinguished. The first two, in the context of traditional technology, call for highly skilled labour, whereas the qualifications required in the other two stages are much lower.

The stages in question are as follows:

- The "creation" which determines what the garment is going to be - as a function of current trends of fashion and the manufacturer's style - this design then undergoing the manufacturing process termed patterning;

- Grading, laying and cutting. Grading consists of determining, on the basis of the prototype garment, the features of the entire range of sizes in which the garment will be produced. Laying consists of determining the most suitable way in which to cut the cloth from which all the pieces intended for assembly into the garment are to be drawn. Cutting is an operation which is normally performed after folding, i.e. the superimposition of several folds of cloth for cutting;

- Assembly, a process which consists - using needle and thread as has been the case since the earliest times - of sewing the various parts together;

- Finishing: the pressing, folding and packing of the garment.

7/ Jacomet, "Le textile - habillement - une industrie de pointe" (Paris, Economica, 1987).

8/ It should be noted at the same time that three quarters of the exports of developing countries originate from four Asiatic countries: China, Hong Kong, the Republic of Korea and Taiwan (GATT, 1986/87).

At present, electronics technologies have been introduced in rather different ways, and a distinction can be made between what happens in the first two stages and what happens in the second two. These two categories will therefore be considered separately.

In the first category, it is computer-aided design tools which have appeared. Even for artists, graphics systems in colour facilitate layouts and their modifications, while grading becomes practically automatic. Equipment of this kind can be associated with cutting tools, which makes it possible to automate the whole of the first two stages of production. In 1982, nearly 20 per cent of the most important companies in the OECD area were equipped with CAD systems, while another 30 per cent were making preparations in this connection. 9/ The combination with cutting systems represents one of the most modern arrangements existing in batch-processing industries. Out of the potential market of about 1,000 large firms in the OECD area already disposing of a CAD system, about 18 per cent would appear already to have the combined equipment. According to K. Hoffman, the advantage over hand cutting could be significant. 10/ Thus, in the case of a firm with an annual turnover of $50 million, the saving in 10 years of operation would be some $3 million.

The impact on the organization of firms is important, particularly because it has a substantial effect on the kind of skills required. The highly qualified jobs of "grader", "layer" and "cutter" are completely changed. The job of grader virtually disappears, and in incompletely integrated systems the laying software is reciprocally acting and the layer retains a skilled job with a new skill at his disposal. The job of cutter does not disappear but becomes largely unskilled: three to five years are needed to train a manual cutter, whereas a few months are enough for him to learn to operate a numerically-controlled cutting machine.

The direct profits accruing to the enterprise basically consist of the saving in cloth, which may exceed 10 per cent, a far from negligible figure. The indirect gains relate to the flexibility and the speed with which new garments can be produced - a very important feature when it is necessary to follow the trends of fashion. On the other hand, new costs arise principally in the field of management and maintenance of these new systems, which require specialist personnel, while in order to derive profit from all the positive features it is necessary to improve stock management, and for increasing flexibility it is likewise appropriate to improve the management of relations with suppliers and customers.

It is at the third stage - that of assembly - that the introduction of electronics technologies causes a problem. This introduction has indeed been made by the use of sewing machines which may take the form of extremely fast numerically-controlled machines, but yielding very limited gains. The reason is that the time actually devoted to sewing in this stage represents only 10-30 per cent of the assembly cycle of an ordinary garment, 11/ the rest being devoted to handling of the cloth. But it is precisely this stage which calls for the most labour - in fact about 80 per cent of the total labour involved in the garment industry. 12/

9/ OECD, op. cit.

10/ K. Hoffman, Microelectronics and Clothing (New York, Praeger, 1988), p. 87.

11/ See Hoffman, op. cit.

12/ OECD, "Revivifier l'industrie par la technologie (Paris, 1988), p. 150 (of the French text).

Industrialists in this sector are well aware that it is here that the introduction of suitable electronic technologies could yield substantial gains in terms of competitiveness. 13/ This is a much discussed issue in several industrial countries, where the clothing sector includes numerous undertakings in difficulties. The research and development effort is, in spite of this, on a modest scale in these undertakings, since here, as in the textile industry, it is the manufacturers of machines who furnish technical progress. Since these manufacturers are independent, their machines are sold on the market and are available to anyone with the necessary financial resources.

At the same time, progress at the assembly stage is still awaited and the authorities in the industrialized countries are actively supporting research efforts in this direction. Thus, for example, in the United States the Department of Commerce is subsidizing a joint project conducted by textile fibre and clothing firms called "TC2", in Japan, the MIT is encouraging the "Technology research association of automated sewing systems" and under the BRITE programme the EEC is supporting research on the automatic maintenance of flexible equipment promoted by European sewing-machine manufacturers.

The developing countries thus retain a traditional advantage in this labour-intensive industry, until such time as radical progress is made in this phase of production. A study of the costs involved 14/ has shown that for manufacture of a good-quality cotton shirt the phase in question represented on average in a Far Eastern country 71 per cent of the cost price prevailing in a European country, the difference residing mainly in wages.

The impact on the developing countries of introducing electronics technologies into this industry would appear to be inevitable within a few years. A number of developing countries have indeed already equipped themselves in this respect, either for technical reasons as when, for example, they purchase machines for sewing collars or pockets, which furnish work of an appearance different from that carried out by hand, or because they are in competition with other developing countries with lower labour costs than their own. Other countries, today, are investing in CAD systems because of the savings in cloth which can be effected, and then it becomes clear that the lower the labour costs, the higher equipment costs are going to appear.

B. Mechanical engineering

The mechanical engineering industry is here considered as one in which electronics systems are involved not only in the production process but also in the product itself, giving rise to what the Japanese have termed "mecatronics". This industry is of considerable importance because it supplies machinery for all manufacturing operations.

13/ See M. Dubois, "L'industrie de l'habillement. L'innovation face à la crise. Notes et études documentaires" (Paris, 1988).

14/ R. Vernet, "Likely technological developments in the textile industry and their potential impact on the future competitiveness of the industrialized countries", COMITEXTIL bulletin 85/5, according to OECD, op. cit., p. 148.

Consideration will first be given to machine tools operating by removing metal (as opposed to those which operate by shaping metal), and we shall observe the trend in the position among these tools held by those incorporating electronics systems and designated numerically-controlled machine tools, receiving their instructions from a computer which programs and monitors their work. In Japan, the proportion in question increased from 17.3 per cent to 51 per cent of production (by value) between 1975 and 1981. The number of these NCMTs produced by the United States, France, Japan, the Federal Republic of Germany and the United Kingdom increased, by a factor of more than five between 1975 and 1983, going from 9,440 units to 48,500 units. Out of 2,000 Japanese firms manufacturing machine tools, about 150 were building these new machines in 1979. This is only a modest proportion, but the number of small manufacturers is very high. In the United States, out of 600 machine tool manufacturers, 20 per cent (including all the large ones) are making NCMTs using a number of instruments termed machining centres. 15/

These figures show the extent of the change and the way it is accelerating. Machine tool manufacturers are ever more obliged to offer products corresponding to the given state of technology, i.e. products incorporating electronics systems. Furthermore, these tools have themselves to be manufactured with the assistance of various NCMTs. It is indeed the mechanical engineering industry which is the one possessing the largest number of NCMTs. In the United States, in 1983, it held 51 per cent of all NCMTs (52,540 units) and 58 per cent of the machining centres (13,920 units). Comparable data are found for Japan in 1981: 44 per cent of NCMTs (11,000 units) were installed in mechanical engineering firms. 16/

Turning from this sectoral distribution of NCMTs, we may now consider their share in the total of machine tools operating by removal of metal; it emerges that the overall level of penetration remains relatively low. In the United States, in 1983, it amounted to 6 per cent of the total number, and in Japan to 4 per cent. But the total numbers involved are extremely large, with numerous types of machine tool. One of these types - lathes - is distinctly more penetrated by electronics technologies. See table 2.

As will be seen from this table, the market for lathes other than numerically-controlled instruments sagged considerably between 1975 and 1984, and in order to survive manufacturers have therefore to consider ways and means of modifying their product. Overall, in 1984, three quarters of the world production of lathes in the market-economy countries were represented, in terms of value, by numerically-controlled lathes.

15/ All these data are taken from a report by the Economic Commission for Europe entitled "Recent trends in flexible manufacturing", United Nations, New York. Unfortunately there are no equivalent data for other groups of countries, and in particular very few relating to developing countries.

16/ Data provided by the Economic Commission for Europe, op. cit., pp. 53-54. In the case of Japan, only firms with more than 50 employees are considered.

Table 2

The share of numerically-controlled lathes in the total investment in lathes in a number of countries
(in per cent)

Year	Federal Republic of Germany	United States	France	Japan	United Kingdom	Sweden
1975	26	17	23	43	19	No data
1984	85	59	71	83	83	73

Source: CECIMO and MBTBA as reported by S. Jacobson, Electronics and Industrial Policy (London, Allen and Unwin, 1986), p. 13.

This remarkable trend has not occurred without affecting the industry world wide. Japanese firms have been the driving force behind the change, manufacturing relatively simple and cheap lathes in large numbers and exporting them to a great extent. In 1984, every second numerically-controlled lathe sold outside Japan was a Japanese product. Japan holds 54 per cent of the world market, in terms of value, exporting 69 per cent of its output in 1981. 17/

The impact on the organization of enterprises manufacturing conventional lathes is of course considerable. In the first place, in this case and in that of all articles where electronics have to be introduced into the product itself, the traditional skill and know-how are no longer sufficient and the qualifications required are not to be found within the profession itself. Certainly, the first NCMTs used by a firm may be conventional machines only slightly modified, to which bought-out numerical control devices have been added. While purchasers of this type of hybrid could be found at the beginning of the 1970s, this is no longer the case.

The very design of the item must be completely rethought, on the basis of knowledge of which at least half is entirely new for the firm. It is necessary therefore either to establish a close association with an electronics supplier and bring together teams from the two firms, or to recruit new staff and organize the dialogue within one's own enterprise. Furthermore, electronics technologies are changing very rapidly and mecatronics is still a new industry, which means that an innovative mentality must be developed.

The new series of numerically-controlled lathes which will be appearing on the market will have a very limited lifetime, not comparable with preceding generations. This lifetime is becoming even shorter: it was estimated at eight years in 1974, five years in 1978 and three years in 1983. The research and development costs for a range of numerically-controlled lathes are nevertheless high - of the order of $500,000 to $1 million. 18/

17/ See Jacobson, op. cit.

18/ See Jacobson, op. cit.

These research and development costs, which as we have said are extremely high for a short product life, make it necessary to reduce production costs and increase sales. Most experts 19/ agree that marketing and after-sales service, along with the numerical control faculty, constitute the principal source of economies of scale, which may mean as much as 30 to 40 per cent reduction of costs, subject to an annual production of about 800 units.

In order to reduce these costs in larger production runs, most of the major manufacturers have begun to introduce flexible workshops. Thus, for example, the Japanese firm Yamazaki 20/ has established such a workshop whose productivity is three times that of a conventional shop: the overall cycle needed to produce a lathe lasts four weeks instead of 12, and the number of operators is reduced from 195 to 39. Such results are the outcome both of the machines installed and of the manner in which they are integrated into a new form of organization of work.

It is evident that the world industry is greatly perturbed by these developments, and that, among firms which survive, the problems of reorganization of work and the introduction of new management and production methods are considerable: all observers stress the difficulties inherent in optimizing the operation of totally or partially flexible shops for reasons which are essentially of an organizational nature, relating to logistics and "human resources".

The developing countries are affected by this trend in two ways: as users of lathes and as producers of lathes. The price of numerically-controlled lathes was very high 15 years ago or so, but this is no longer the case. Whereas in 1974 Japanese prices 21/ were more than eight times higher than for conventional lathes, the difference had been reduced to a factor of 3.5 to 1 by 1984 and is tending to drop still further for machines which are also as a rule faster and more accurate. This might encourage the developing countries to purchase NCMTs for their metalworking and mechanical engineering activities.

There are also about a dozen developing countries manufacturing machine tools, and in particular conventional lathes. All these countries have already been obliged to undertake the manufacture of numerically-controlled lathes. Apart from an impact of the kind felt by any conventional manufacturer and described above, a firm in a developing country may find itself unable to solve the problem of purchasing the electronics know-how locally, in its efforts to proceed from mechanics to mecatronics.

In the case of Brazil and India, F. Erber considers 22/ that these countries are experiencing difficulties in effecting the technological transformation.

19/ Economic Commission for Europe and BCG "Strategic study of the machine tool industry" (1985).

20/ See UNIDO, "Global study of world electronics" (ID/WG.478/2(SPEC.), 1988), p. 108.

21/ See Jacobson, op. cit.

22/ "Capital goods in industry and the dynamics of economic development in LDCs: the case of Brazil", in M. Fransman, ed., Machinery and Economic Development (Macmillan, 1986), pp. 215-245.

Their market is too small and their customers, including public undertakings, tend to prefer imported products, thus depriving them of a period and a sphere of apprenticeship based on imported technologies.

The position of countries such as the Republic of Korea, having a greater electronics technology potential, is very different; nevertheless, numerous problems still arise. According to S. Jacobson, the strategy of all manufacturers in the most advanced developing countries has consisted of producing the least sophisticated and the cheapest types of lathe. This strategy will not work in the long term; at best it can provide an interim period for re-learning. In the medium and long term it will be necessary, in order to remain an effective lathe manufacturer, to launch out into the production of the types for which there is the greatest demand. Here it seems essential that the public authorities in the developing countries concerned should adopt strong support measures and lay down a clear strategy. This undoubtedly requires thorough study.

III. ASPECTS TO BE CONSIDERED FOR PLACING ELECTRONICS TECHNOLOGIES AT THE SERVICE OF INDUSTRIAL DEVELOPMENT

A. The ability of electronics technologies to promote industrial development

In most spheres, the penetration of electronics technologies has been slower than was believed at the beginning of the 1980s. It was thought at that time that the advantages accruing from labour costs and enjoyed by the developing countries would soon disappear and that production based on these advantages would revert to the more industrialized countries. In fact, a considerable range of industrial operations may continue to be carried out in developing countries using conventional techniques.

The developing countries may choose activities in which they wish to promote the penetration of electronics on the basis not only of benefits in terms of productivity, quality and specificity of product, but also of advantages enabling them to structure their industrial production apparatus in the way which will be necessary at the start of the third millenium.

B. Socio-economic adjustments implied by the use of electronics technologies

The examples represented by the clothing and machine-tool industries have clearly shown that, at micro-economic level, the user of electronics technologies was able to reduce the number of workplaces without necessarily lowering employment at the firm or group level. Most of the studies conducted in industrialized countries show that the macro-economic results are not negative. This does not mean that the macro-economic result is spontaneous, but it indicates rather that supporting policies of an institutional and financial nature are necessary in order to facilitate the reorganization of the socio-economic system.

These examples demonstrate the need to reorganize operations in the widest sense, within the enterprise. The skills required for former jobs are modified, others disappear altogether, and new ones become necessary. The old kinds of know-how are no longer suitable or must be combined with others which may be available in the enterprises with which co-operation must be pursued. In addition, the necessary intra-enterprise co-operation on the part of workers and a display of

interest in the organization of the work in progress seem to play more important roles than formerly. 23/ We are clearly faced with a new concept of labour, which calls for substantial socio-economic adjustments characterized by greater job flexibility and greater worker participation.

C. Training requirements for mastering electronics technologies

Training is of course one of the most important requirements. Whereas a number of traditional jobs disappear or no longer call for special skills, new jobs requiring moderately or highly skilled personnel are necessary to implement and master electronics technologies.

It is sometimes thought that the developing countries have available abundant skilled labour. One would do well to ponder this affirmation, in view of the fact that the obstacle most frequently mentioned in the industrialized countries in connection with the introduction of electronics technologies in a firm is shortage of staff skilled in electronics. 24/ The new skills called for by problems of production and labour organization should also not be forgotten.

D. The need to develop repair and maintenance capabilities appropriate to the new equipment

One of the most common dangers lying in wait for the potential user of new equipment, whose manufacturer is not close at hand or only whose base purchase has been financed, is that the equipment may soon break down or even may never function.

Most electronics systems require after-sales service and systematic maintenance, normally offered by the manufacturer or by specialized service companies. These operations are expensive and it is normally preferable that companies should carry them out themselves, at least to some extent. But even current maintenance and small-scale repairs, in the case of this type of equipment, still require skilled staff and suitable facilities.

The repair and maintenance of such equipment in some ways also provides technological apprenticeship. These operations can thus contribute to industrial development.

E. The importance of regional and international co-operation

Regional or international co-operation concerned with the use of electronics technologies in industrial production should concentrate on the transfer of the experience gained from such use. Through highlighting the basic problems to be solved, co-operation could lead to a reduction of the difficulties, particularly of an organizational kind, which emerge during introduction of electronics technologies.

23/ See J. C. Neffa, "Proceso de trabajo, nuevas tecnologías informatizadas y condiciones y medio ambiente de trabajo en Argentina" (Buenos Aires, Friedrich Ebert, 1988).

24/ See Northcott, op. cit.

As regards training, and during the first stages of introduction of the new technologies, regional training centres and international agreements would be in a position to launch a process which is difficult to initiate at national level owing to the shortage of instructors.

Similarly, the use of various items of equipment at least to some extent not locally produced and involving entirely new electronics technologies gives rise to repair and maintenance problems which are also, in the early stages, training problems where regional and international co-operation has its part to play. The establishment of spare parts stocks or of remote control maintenance centres (by telecommunications) is a further matter for regional co-operation.

IV. FINAL CONSIDERATIONS

The world technological and industrial transformation is causing practically all countries to aim at "modernizing" their industrial production apparatus, in order to keep pace with the electronics age. The background, procedures and implications of the spread of electronics technologies as described in this document would suggest that discussions aimed at reaching conclusions and drafting recommendations should be organized on the following subjects:

Impact of the diffusion of electronics technologies on industrial activities as a whole

- All industrial sectors are concerned, in terms either of production processes (automation) or of products incorporating ever more electronics. The developing countries should therefore pay attention to these developments and consider their consequences.

- The automation occurring in industrialized countries may progressively undermine the favourable position won by the developing countries in certain sectors of the world market; this is particularly so in the clothing industry, mechanical engineering, automobile component manufacture, machine tools and the electronics industry itself.

The choice between conventional processes and automated processes in the developing countries

The decisions here should be made gradually, taking into simultaneous consideration:

- The advantages offered by automation as regards improvement of productivity and of quality;

- The implications in terms of maintenance and repair of the new equipment installed;

- The position of the sector in question against the background of international competition: automation should start with those sectors which are the most exposed to competition (on the local or world market) and those in which national production is not sufficient to meet local demand;

- The possibility of simultaneously shaping their production structure in the way which will be necessary in order to meet the technological challenges of the third millenium.

Socio-economic adjustments

The public authorities should anticipate and give support to the restructuring operations which will certainly ensue from the introduction of electronics into various industrial sectors:

- By offsetting the negative effects of this restructuring (disappearence of jobs or of skills) through institutional or financial measures;

- By promoting the exchange of information (at national and regional levels) and making enterprises aware of the organizational difficulties which will undoubtedly afflict them as a result of automation (changes in skills needed, new forms of co-operation between various jobs, and between design offices and operators). This pooling of experience will make it possible to find solutions to palliate the difficulties.

Training requirements to master electronics technologies

Action to be taken in this field comprises:

- Identification of the new skills required by the introduction of electronics and the reorganization of work;

- Promotion of national and regional training centres in the context of international co-operation.

Development of repair and maintenance capabilities

This should be regarded as a priority calling for:

- The promotion of training in the conduct of current maintenance;

- Study of the advisability of regional co-operation which could take the form of a maintenance centre remotely controlled by telecommunication, or of the establishment of a stock of spare parts.